Space Weather Technical Forecast

Issued on Saturday, 18 March 2023 at 13:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Storm intervals with CME glance possible day 3 or 4 (20th or 21st) but low confidence. Chance of M-flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with peak flare of M1.0 at 17/1507UTC. This peak comprised of an impulsive flare from AR3254 in the southwest, overlaid on a much longer-period C6 flare from AR3256 in the southeast. A further impulsive C9.4 flare was observed from AR3256 at 18/0716 UTC. Of the three visible sunspot regions AR3256 is the most complex in the southeast disc, with more complexity becoming apparent as it rotates into view. This is a wide group, consisting of a large leader and smaller trailer with some ongoing flux emergence around both these spots. A further unnumbered sunspot to the southeast of this region is also moving into view. The other two numbered regions are much simpler with AR3254 fading to plage as it rotates off the visible disc and over the southwest horizon.

A series of filament eruptions have occurred in the last 24 hours. The most notable was a 30-degree longitude spanning filament, which left the southwest disc just before this period, at 17/1100 UTC but with the CME observed during it. Available coronagraph imagery for analysis is limited, giving a broader range of possible solutions than would ordinarily be the case. After some reassessment, this is now considered likely give a glancing impact late on day 3 or early day 4 (20th or 21st), although most of the material is still expected to miss to the south and ahead of Earth. Smaller filaments were also observed lifting from the northwest disc at 17/1800 UTC and 17/2100 UTC. Any CME from this location would have the potential to be Earth-directed, however none has currently been observed. Confidence is low with the geomagnetic forecast due to these eruptions.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1, was slightly elevated at around 400-460 km/s throughout, with density near average. The total IMF strength Bt, was weak between 5-7nT, with the north-south component Bz ranging between +/-6nT. The phi angle was predominately positive (away from the Sun). Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 is slightly above background, but now below 1pfu and continuing a slow decline after the enhancement on 13 March. The high energy electron flux (greater than 2MeV) has been at background with the associated 24-hour Electron fluence below Active (1e8 integrated pfu). At 18/0000 UTC the observed fluence was 2.9e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is most likely, but with a chance of increasing to Moderate at times with isolated M-flares throughout. These most likely AR3256 in the southeast, or from other regions rotating onto the southeast disc, and also onto the northeast disc later in the period.

Solar Wind / Geomagnetic Activity: A glancing CME impact is possible day 3 or early day 4 (20th or 21st), however this is low confidence. This will come alongside a muted connection to the fast wind from CH84/+. Geomagnetic activity is expected to be mainly Quiet until this HSS

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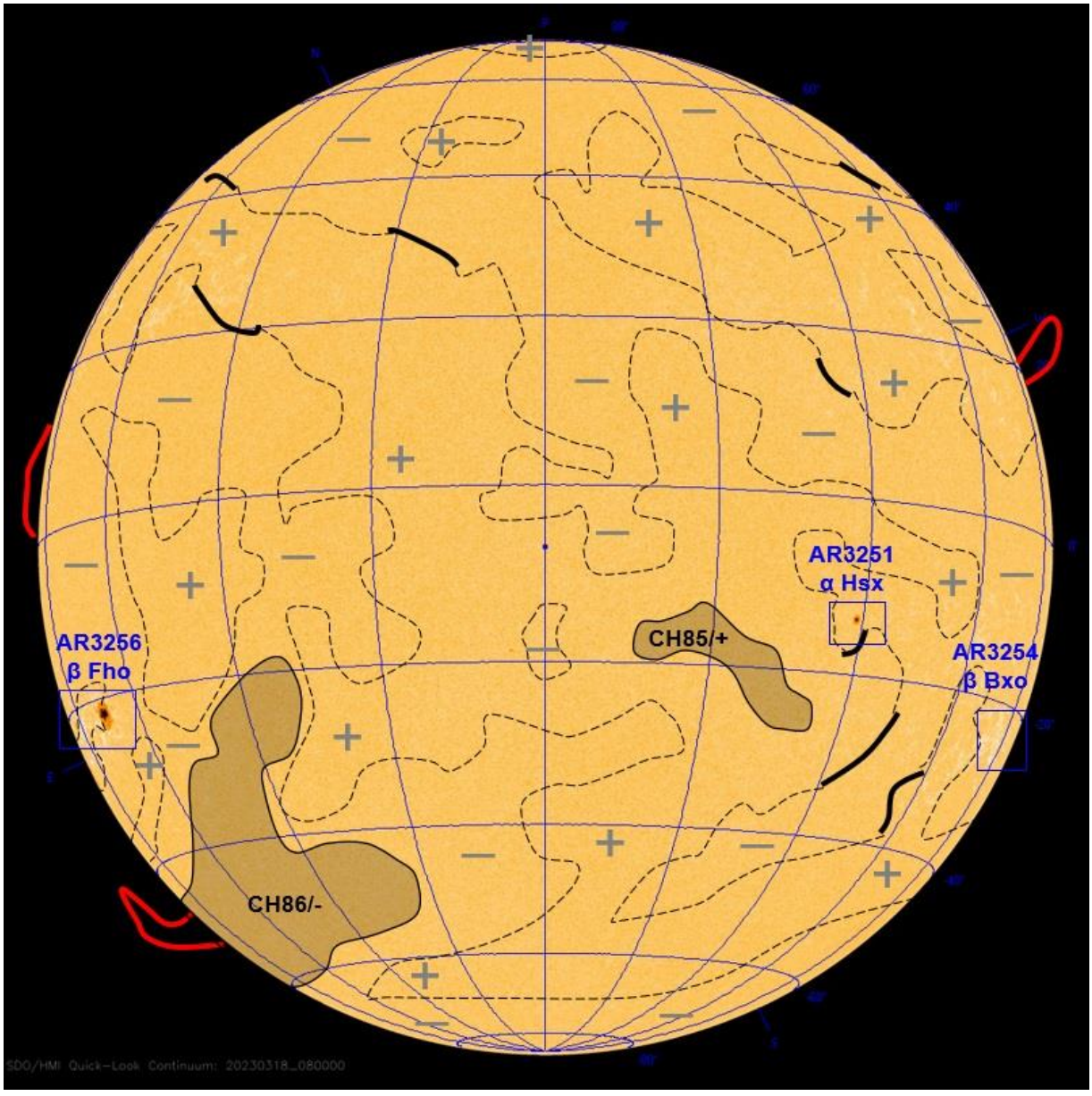
arrival, then becoming Unsettled with Active intervals likely. Any CME arrival will likely increase this further, to Active to G1 Minor Storm intervals. Activity then likely easing later day 4 (21st).

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to continue easing to background, with no further significant enhancements currently anticipated. The high energy electron flux is expected to persist at background, perhaps rising a little day 4 (21st) as a result of the connection to CH84/+ and any CME arrivals. Confidence is low for any notable increase however, with the associated 24 hour fluence expected to remain below the Active threshold.

Figure 1. Solar Analysis Valid 18/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

CME from 17 March has been assessed as passing mostly ahead and south of Earth, but with a glancing impact likely late on the day 3 or early day 4 (20th or 21st). This is a low confidence forecast as coronagraph imagery is currently limited.

There is one small coronal hole feature expected to influence conditions at Earth during the next four days, CH84/+. The fast wind associated with this feature has the potential to bring some increased geomagnetic activity day 3 (20th) as Earth moves into its HSS. In the absence of any CME arrival this would likely be rather muted due to the Russel-McPherron effect resulting in positive features connecting less strongly near the March Equinox, perhaps peaking at Active with only a very slight chance of G1/Minor Storms. However, alongside the low confidence CME, there is a chance of activity increasing to G1/Minor storm later day 3 (20th).

Mainly Quiet geomagnetic activity is forecast day 1 and 2 (18th and 19th), increasing to Unsettled with Active intervals with any fast wind transition into day 3 (20th), easing day 4 (21st). This perhaps increasing to Active to G1 Minor storms with any CME arrival. . Activity then likely easing later day 4 (21st).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	30	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/1610 UTC	Partial	Filament	SW	510 km/s	20/2100 UTC +/- 9hrs	Low confidence Glancing impact, with most material missing.

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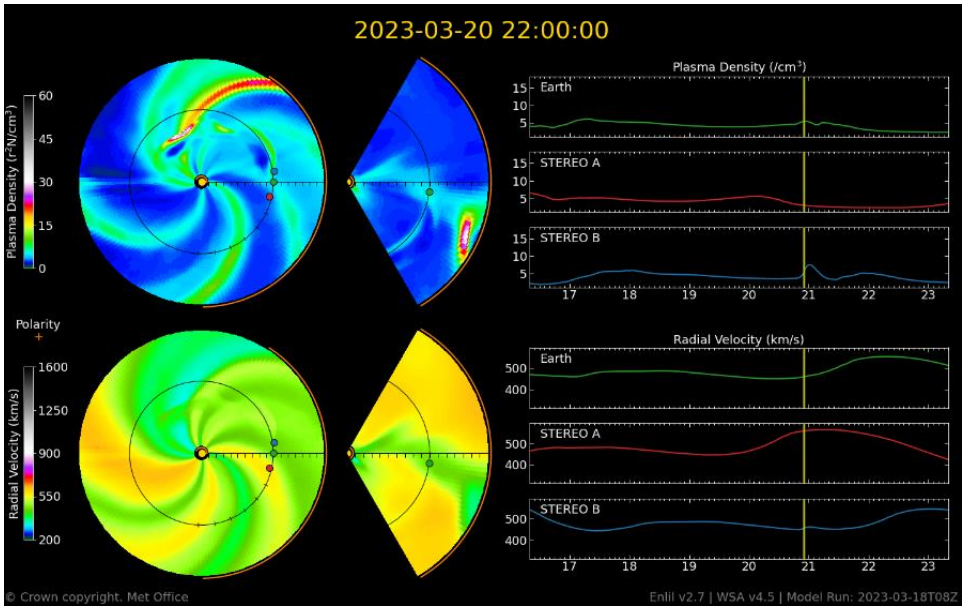
Figure 2a: Enlil and Ensemble. Most of the CME shows passing south and ahead of Earth, but glancing impact possible.



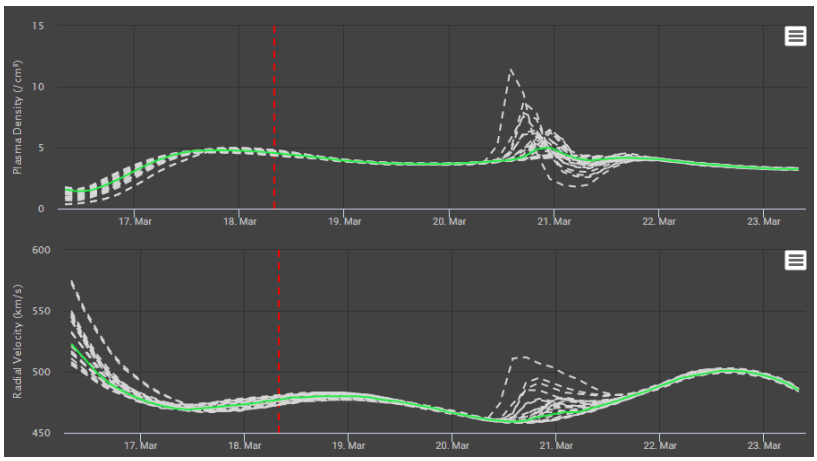
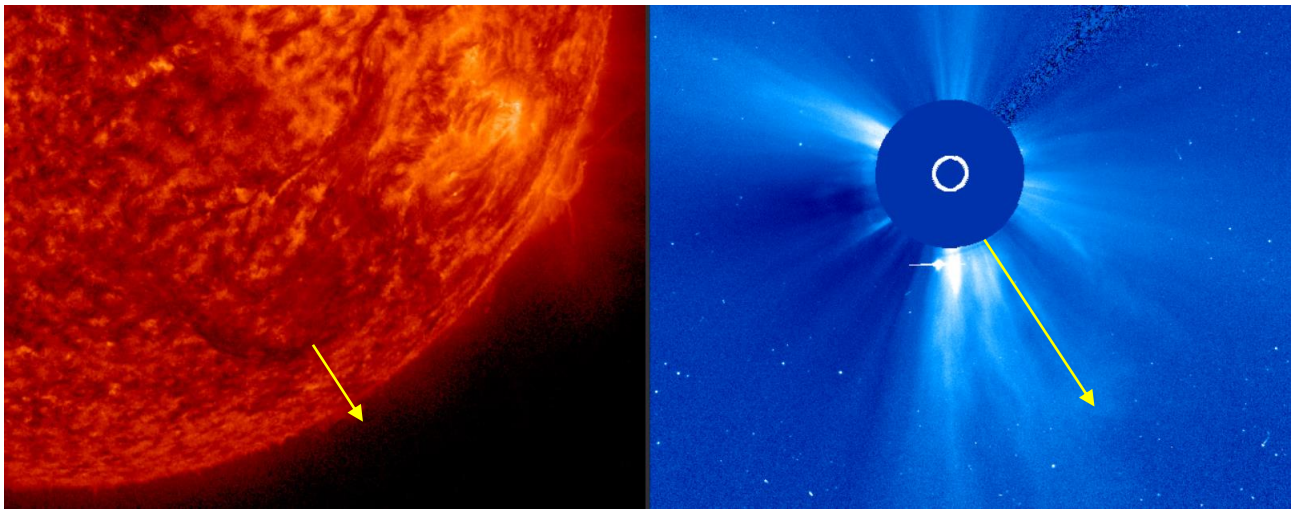


Figure 2b: SDO aia 304 (left) showing eruption. SOHO LASCO C3 (right) showing CME to SW.



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Radio Blackouts - X-Ray Flares:

Mainly Low activity is expected, with a chance of rising to Moderate. There is also a very slight chance of this rising to High. AR3256 Fho/Beta-gamma is currently the most notable numbered region on the disc, comprised of a large leader with some flux emergence around it and a smaller trailer, also with smaller spots. As this moves into a less oblique viewing angle more complexity is gradually been becoming apparent, although it may yet be more appropriate to split this into two smaller separate sunspot regions. The other numbered regions are smaller and simpler.

A further unnumbered region to the southeast of AR3256 is also becoming apparent. Despite being on the limb, a strong trailer spot is already identifiable, with a potential leader, along with an east-west aligned polarity separation line. Coupled with the bright flux visible on STEREO-A euvi and significant magnetic looping on e.g. SDO aia-171, these all point to an increased flare potential. Significant looping is also evident over the horizon in the northeast disc. This is potentially due to the region that was responsible for the large far-side CME on 13 March, which may be returning ex-AR3243. This also ties in with a strong helioseismic signal, and while not expected on the Earth-side until day 4 (21st), has the potential to bring visible flares preceding this date. Overall, this bring a slight chance of strong flares, although this forecast will be refined further as these regions become more visible.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	Yes	30	30	30	30
Very Active	**R3 to R5 X Class**	No	5	5	5	5

Figure 3a: GOES-16/18 X-ray Flux

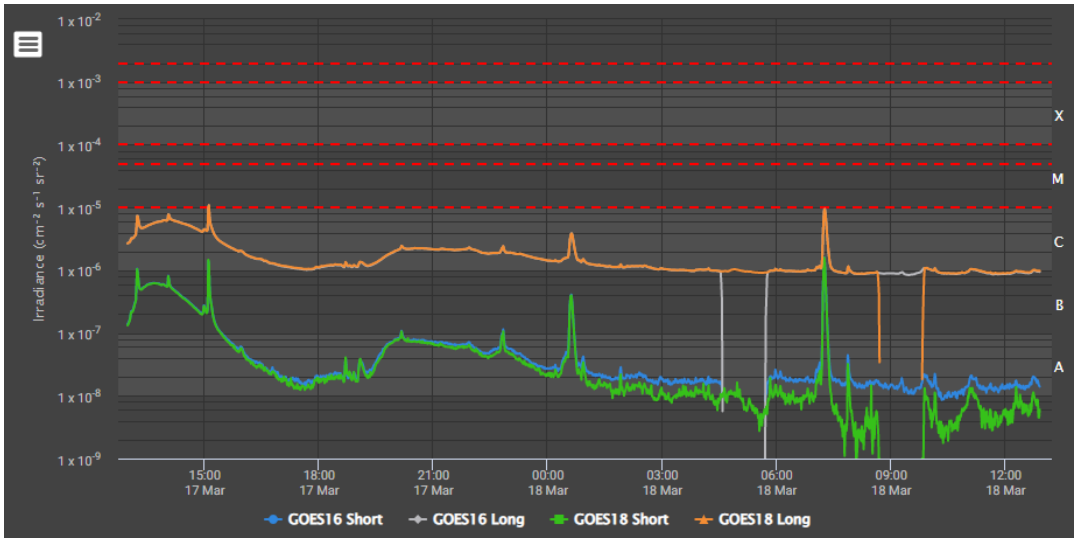

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Figure 3b: SDO hmi-Intensitygram and magnetogram of AR3256 in the southeast and new region becoming visible.

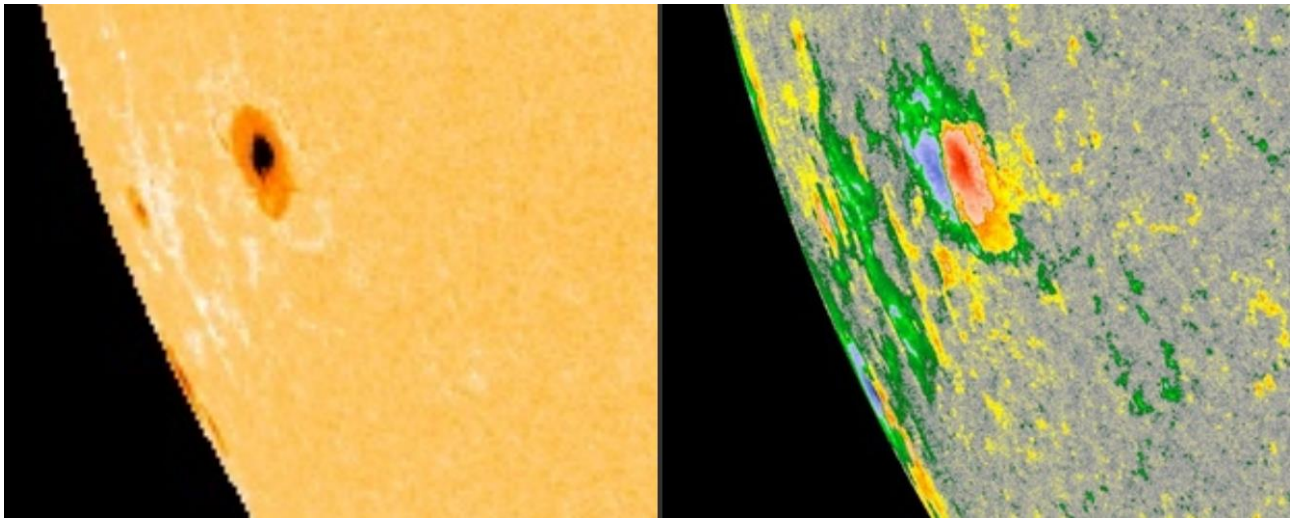


Figure 3c: STEREO A euvi (left) and SDO aia-171 (right) showing significant magnetic looping on east limb

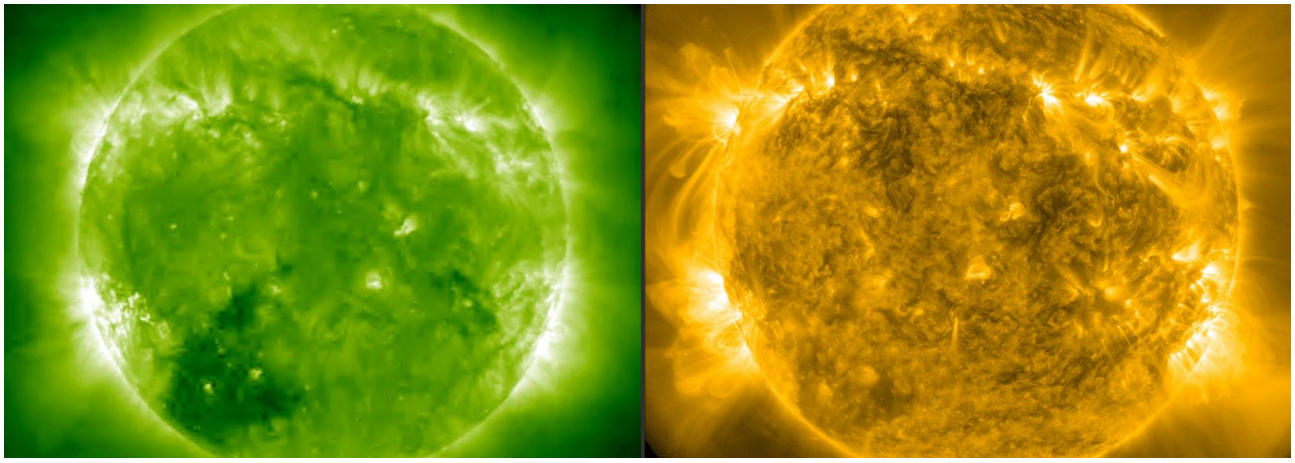
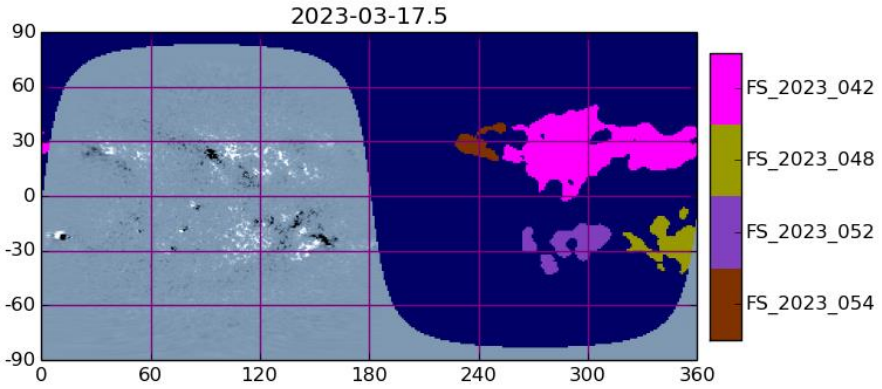


Figure 3d: Helioseismic signal of far-side regions (from jsoc.stanford.edu). Significant region in the north is coincident with ex-AR3243 and would be a reasonable source for the far-side event on the 13th



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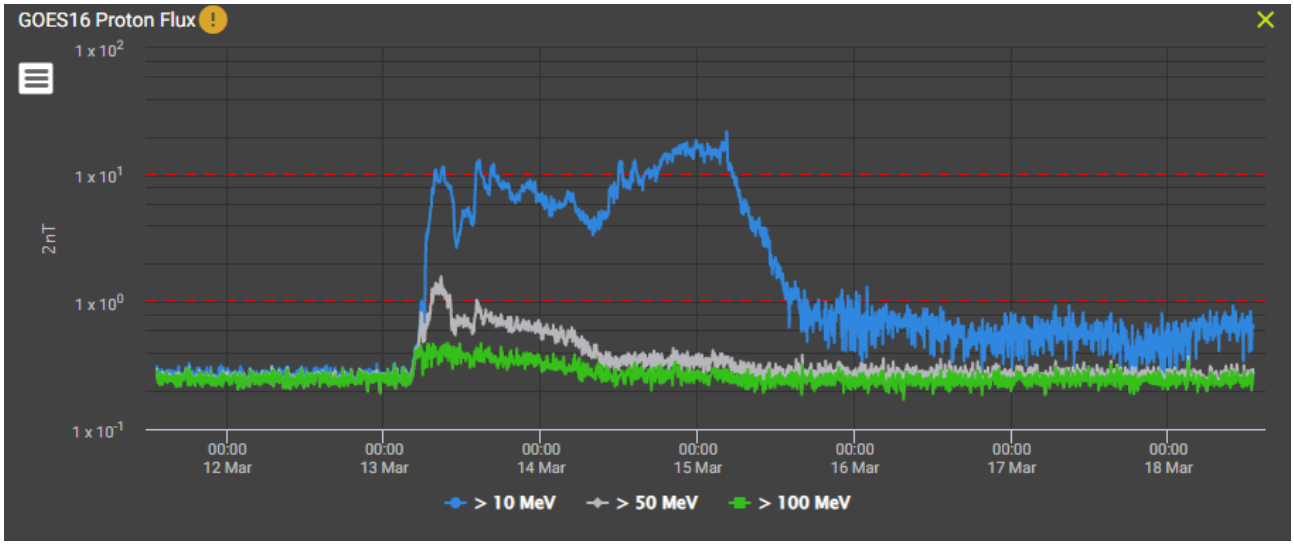
Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES-16 is currently very slightly above background as it continues to gradually decline from the S1 Minor Radiation storm event earlier this week. No further notable proton enhancements are currently anticipated, with the most notable sunspot regions in a less favoured region for connection to Earth should any significant flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100MeV proton flux over the last 7 days.



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High Energy Electrons Event (≥ 2MeV):

The high energy (>2MeV) electron flux observed by GOES-16 is currently mainly at background, with no significant enhancements now expected until at least day 3 with the transition into the fast wind of CH84. This enhancement is also expected to be muted, and alongside the potential for a CME glance on day 3 or early day 4 (20th and 21st), confidence remains low for any notable increase in flux levels beyond this date.

The associated 24 hour fluence is expected to be below the Active (1e8 integrate pfu) level with REFM currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >2MeV electron flux and associated fluence with REFM

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